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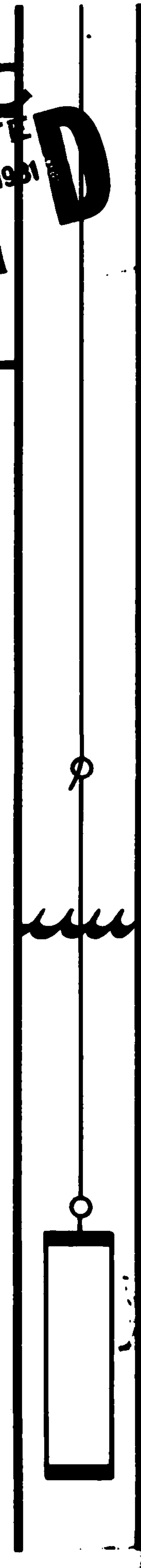
GEM--A Simple Meteorological Buoy With Satellite Telemetry

A small meteorological buoy suitable for mesoscale research ~~has been~~ developed at NOAA's Pacific Marine Environmental Laboratory. The GEM (GOES Environmental Monitor) buoy transmits data via the GOES satellite, which eliminates the need for internal tape recording. Vector averaged winds, scaler winds, air temperature, water temperature, and maximum gusts are measured.

A sketch of the buoy moored in 100 m of water is presented. ~~in Figure 1.~~ The hull is a 1-m-diameter, foam-filled aluminum sphere with a .38-m-diameter cylinder extending through the center. ~~as shown.~~ When ballasted to the equater of the sphere, the buoy displaces 260 kg. The natural frequency in pitch and roll is approximately 1.8 seconds, but the suspension of a 120 kg weight 10 m below the buoy provides a double pendulum which effectively damps high frequency wave excitation.

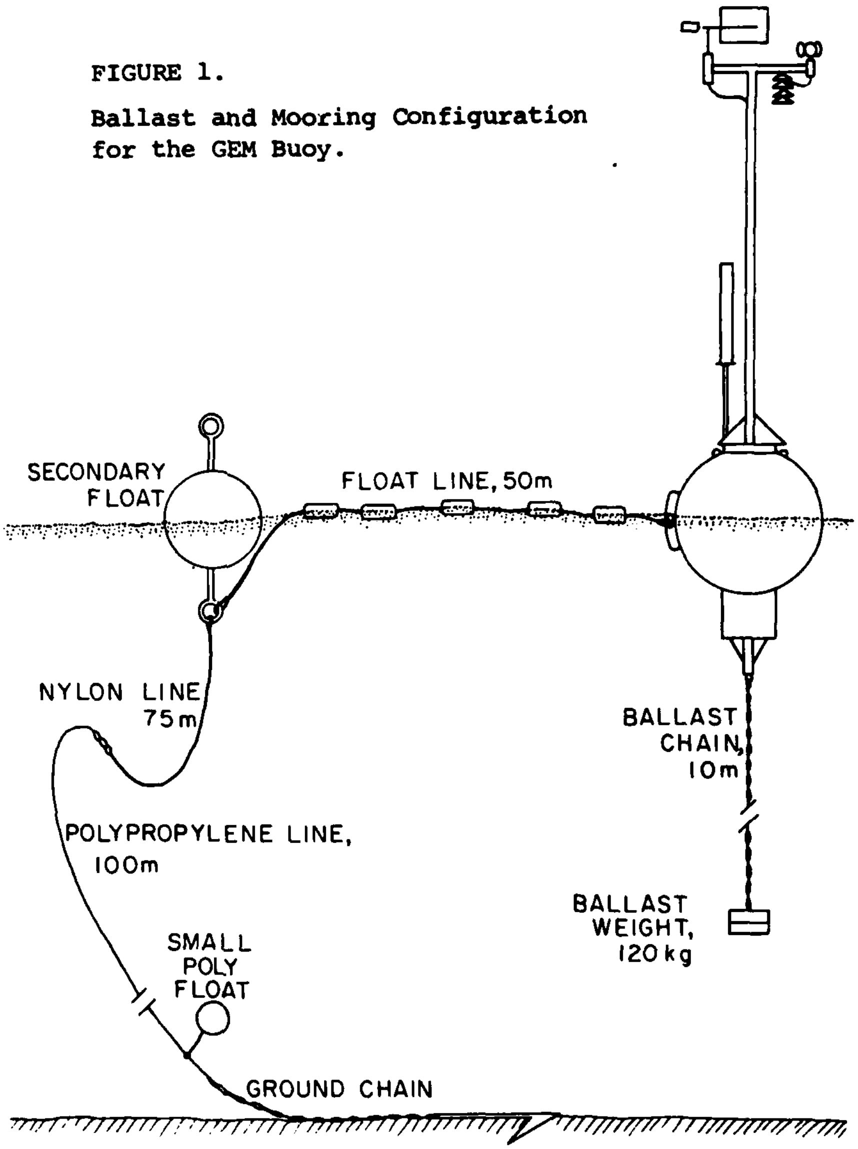


July 1981

The buoy is moored to a secondary float with a stiff plastic coated line that is made buoyant and visible with foam floats attached every two meters. The line is attached at the center of drag of the buoy hull to minimize inclining forces. The secondary float is moored with a reverse catenary mooring with a scope of 2:1. The upper section is nylon and the lower section is polypropylene. A small float is used to keep the lower end of the line off the bottom to prevent chafing. the anchor used is a 45-lb Danforth with 10 m of chain or a 600 lb deadweight, depending on bottom characteristics (and availability of anchors).

FIGURE 1.

Ballast and Mooring Configuration for the GEM Buoy.



The sensors are supported 3 m above the water on a 5 cm o.d. aluminum mast. Meteorological parameters are measured as follows: wind speed is measured with a Young model 6101 3-cup anamometer; relative wind direction is measured with a Young model 6301 vane assembly; buoy orientation is measured with an ENDECO model 869 flux-gate compass which is located with the electronics; air and water temperatures are measured with thermistor-controlled oscillators. The air-temperature oscillator is located in a Climatronics sunscreen assembly just below the anemometer cross-arm and the water-temperature oscillator is located at the bottom of the hull cylinder at a depth of approximately one meter.

TABLE 1

METEOROLOGICAL PARAMETERS MONITORED BY GEM

Quantity	Resolution	Averaging Times (SEC)
Vector Winds	.2 ms^{-1}	640
Cup Speed	.2 ms^{-1}	640
Vane	2 degrees	64
Air Temperature	.005°C	64
Water Temperature	.005°C	64
Gust Maximum	.2 ms^{-1}	Instantaneous
Buoy Direction	2 degrees	Instantaneous

The meteorological parameters measured are given in Table 1. A unique feature of the buoy is the vector averaging technique, which does not use a microcomputer. A digital sum of compass and vane positions is used as an address to obtain a sine and cosine from a specially programmed read-only-memory device. The trig functions are then combined with the cup voltage in a digital to frequency converter to generate two square waves whose frequencies are given by

$$f_x = Kv_c \sin(\phi_v + \phi_c), \quad (1)$$

$$f_y = Kv_c \cos(\phi_v + \phi_c), \quad (2)$$

where v_c is the cup output in ms^{-1}, ϕ_v is the vane angle, ϕ_c is the compass angle, and K is a conversion factor. Frequencies are updated at a 100 H_z rate, and averaged for 640 seconds. From these averages vector-mean wind velocities are determined. For added reliability a direct average of the anemometer output is converted to a frequency and integrated for the same period.

The cups are calibrated in the University of Washington wind tunnel and the compass and vector-averaging system is calibrated in Lake Washington at the NOAA facility by surveying techniques. System accuracy is estimated to be ± 0.4 ms^{-1} in each vector component.

The vane signal is averaged directly for 64 seconds, but before integration, corrections are made for transitions from 0 to 360° or back which will ruin a simple average of direction. A switching analog amplifier recognizes these transitions and adds or subtracts 360° to the signal to yeild a 0 to 540° output. Signal jumps are reduced considerably by this technique, and seldom happen during a sample period. Whenever such a transition occurs, the bad sample is easily recognized and removed. The vane average, when combined with the instantaneous compass reading described below, gives an estimate of wind direction. In tests conducted to date, this measurement is certainly suitable for approximate wind estimates, but is much noisier than the vector-mean wind direction.

Air and water temperatures are measured with thermistor-controlled, square-wave oscillators. Thermistor and oscillator circuits are molded as a unit in small housings to reduce differential temperature and noise effect. The temperature sensors are calibrated with a laboratory counter and a quality temperature bath.

The gust measurement is made by recording the maximum signal from the cup during the 640 seconds average period in a peak detector. The signal is filtered by a first-order, low-pass filter with time constant of .5 seconds yielding a response similar to a dial gauge. Hence, the peak is more nearly equivalent to a reading which was made manually.

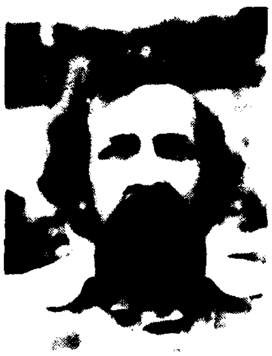
Finally, an instantaneous reading of the buoy compass is stored. Without such data, a compass malfunction might be lost in the vector-average process and therefore be undetectable. Further, the mooring configuration causes the buoy to align itself in some manner with the wind, sea, and surface current; the latter being the dominate force in most cases. Since the compass orientation with respect to the mooring point is known, the general direction of the dominant force is also known.

All data is transmitted to the Geostationary Operational Environmental Satellite (GOES) and on-board tape recorders are used. Among obvious advantages of this technique are immediate knowledge of malfunction or damage, timely data processing, and the ability to use the buoy operationally during an experiment. The GOES system offers near worldwide coverage from five satellites. Two GOES satellites operate on the equator at 75°W and 135°W, so that data can be collected from any place in North and South America, and from Australia to Africa. Over Europe and the Middle East, METEOSAT offers a similar service, while the USSR and Japan maintain GOES satellites over the Indian Ocean and the western Pacific Ocean, respectively.

Several companies make data collection platforms (DCP's) for data transmission to GOES. Most are special-purpose units which do not meet the needs of a meteorological buoy. The GEM buoy uses modified HANDAR model 625A DCP which has a 40 W output power. An omni-directional antenna must be used in this application due to changes in buoy orientation with respect to the GOES satellite. The extra power (most DCP's transmit only 10 W power) provides some insurance of adequate signal strength under adverse transmission conditions. The DCP is programmable to accept and store data at regular intervals, and transmit the stored data to GOES during time windows assigned by the National Environmental Satellite Service (NESS). The data is retransmitted from the satellite to a receiving station at Wallops I., Virginia, and is stored in the World Weather Building at National Weather Service Headquarters. Data is ready for dissemination by phone within seconds after a DCP transmission via interactive callup from a user terminal or computer.

Three field trials of over a month duration each have shown the system to perform well. No tangling of the surface line has occurred, and during one deployment in the Bering Sea a GEM buoy became heavily iced in

Beaufort 6 weather (sustained 40 kn winds), but was observed to be riding well. Data collected to date has been very encouraging, but refinement in the buoys and electronics and intercomparisons with accepted standards are being planned to further our confidence in the system. In addition to the planned use in mesoscale meteorological research experiments, the GEM system shows promise for monitoring the important parameters for pollution-trajectory prediction.



Michael Reynolds is an oceanographer with Pacific Marine Environmental Laboratory, NOAA, in Seattle, Washington. He has a BSEE degree from Southern Methodist University, an MS degree in Meteorology from Melbourne University (Australia), and a PhD in Atmospheric Sciences from University of Washington. He is active in instrumentation for boundary-layer meteorology and air-sea interaction and has contributed to a variety of experiments in these fields.

Hugh Milburn is the group leader for Engineering Studies at NOAA's Pacific Marine Environmental Laboratory in Seattle, Washington. He is involved in the development of a broad range of oceanographic instrumentation. He holds a BMSE degree from California State Polytechnic University and a MSE degree in Ocean Engineering from the University of Washington.

FOR FURTHER INFORMATION, CONTACT:

Mike Reynolds, Hugh Milburn, or
David Gardner
NOAA/Pacific Marine Environmental Laboratory
7600 Sand Point Way N.E.
Seattle, WA 98115

Telephone: (206) 442-7327

David Gardner is presently a member of the NOAA Commissioned Corps and is assigned to the Engineering Studies Group at NOAA's Pacific Marine Environmental Laboratory. He works in support of the engineering activities of the Laboratory and is presently responsible for the development of an acoustic system for volume backscattering studies. He holds BSOE and MSOE degrees from Florida Atlantic University.

A Battery Backup Power System For The PET Microcomputer

Computer programs in memory are subject to loss during power transients. This can be very frustrating if extensive operator duty is required to get the program up and running or valuable data is lost during an experiment. To eliminate this problem for the PET Commodore microcomputer, a battery backup power system has been developed. With a single battery, as shown schematically in Figure 1, a power line interruption of over 20 minutes can be tolerated before memory failure occurs.

A Gel/Cell rechargeable battery, by Globe-Union Inc., was chosen as the backup power source. According to the manufacturer, this battery can be mounted in any position and still be recharged numerous times. The manufacturer recommends float charging their batteries at 2.25 V per cell for the most enduring standby service.

This battery application for the PET takes advantage of the transformer rectified output voltage being at 9 V which serves as a

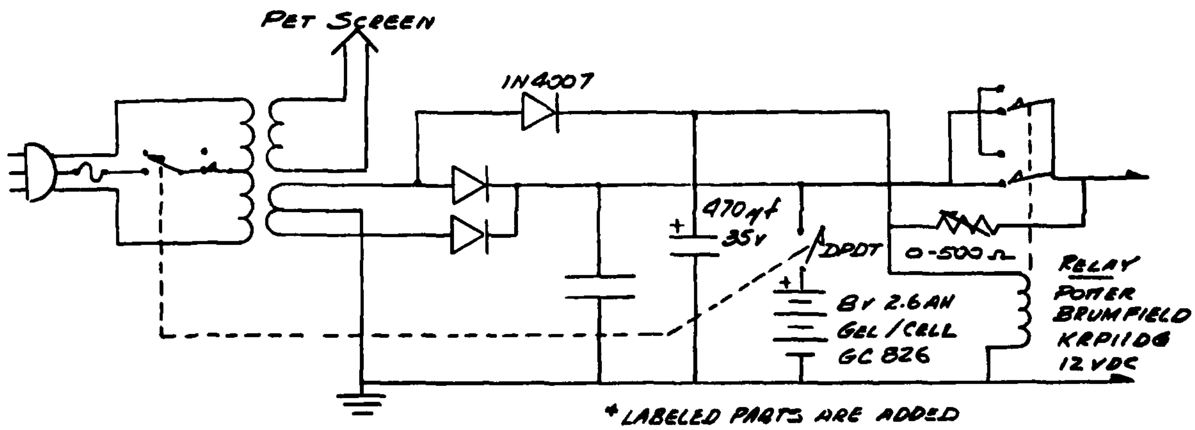


FIGURE 1.

floating charge voltage. The battery is therefore connected directly across the primary d.c. power supply circuit of the PET, as shown in Figure 1. The battery is considered maintenance-free, but it should be recharged as soon as possible after discharge and stored in a charged condition. Overcharging of this battery should be minimized to prevent outgassing. The added relay is activated when the PET is on line power and is held on by the battery when line power fails. When the computer is operating on battery power, and the battery voltage drops below 6.2 V, the memory will fail.

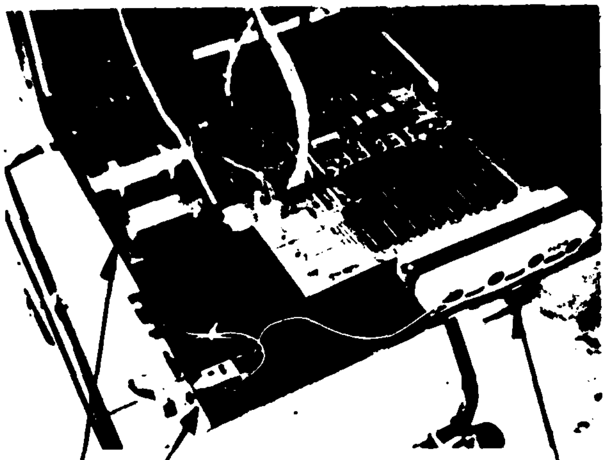


FIGURE 2.

There is no reason to continue to discharge the battery when the memory loss occurs. Therefore, to stop the battery discharge, the potentiometer in Figure 1 has been set to have the relay drop out when its output voltage drops to 6.1 V. When line power returns, the relay will close and provide for recharging the battery. Longer power failures could be accommodated by putting two batteries in parallel. Two batteries would double the reserve line power down period. Adding more than two batteries could exceed the capabilities of the diodes in the transformer circuit during the initial charging period. Another power-on switch needs to be added for the battery application. The regular PET power switch must be on all the time and the added DPDT switch is used to control all of the power to the PET. In our case, the DPDT switch is placed on the forward left side of the cabinet base, as shown in Figure 2, to allow easy access and to be protected by the upper cabinet overhang.

When a power interrupt occurs, the CRT display is cut off because it requires a.c. power; however, the battery adaptation can be a reliable power backup system that can save memory reloading time after temporary power outages.

FOR FURTHER INFORMATION, CONTACT:

John Clardy/Rod Mesecar
Tech. Planning & Development Group
School of Oceanography
Oregon State University
Corvallis, OR 97331

Telephone: (503) 754-2206

John Clardy came to the School of Oceanography as a research assistant in November, 1980, after working for 14 months as a logistics engineer with Boeing Aerospace Company, Seattle, Washington. He received a BS degree in Electrical Engineering from Washington State University. John is currently working on the development and fabrication of electronic instrumentation for oceanographic research.

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Dr. Rod Mesecar, Editor
E X P O S U R E
School of Oceanography
Oregon State University
Corvallis, Oregon 97331

Telephone (503) 754-2206

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